Alginates as haemostatic agents: worth revisiting?

Patients today present with complex wounds which can cover large surface areas, have undermining, be a mixture of tissue types, be highly exuding and show signs of infection. The goals for the treatment of each individual vary. This increases the demands on dressings, as they need to be absorbent, assist in the debridement process, reduce the bacterial burden and prevent maceration. Alginate dressings are now well-established, being used for their conformability, absorbency and ability to provide a moist wound healing environment (Thomas, 2000), however, alginates are also used extensively in other fields such as dentistry as valuable haemostatic agents (Kaneda et al, 2008).

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KEY WORDS
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Haemostasis
Exudate
Cavity wounds
Bleeding wounds

When alginate dressings were first launched many were also presented as haemostatic products. For example, in dental care, alginate products are used extensively to control bleeding in tooth sockets (Kaneda et al, 2008).

Many patients present with wounds which are bleeding or prone to bleeding, and so cannot be treated with a non-interactive dressing. These wounds include:

- Partial- and full-thickness wounds
- Arterial and venous ulcers
- Diabetic foot ulcers
- Pressure ulcers
- Fungating lesions
- Post-surgical wounds
- Toe nail avulsions
- Donor sites
- Traumatic wounds
- Wounds post debridement (sharp, surgical or hydrosurgery).

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Traditional roles of alginate dressings

Alginate products are viewed as being biocompatible, hydrophilic and biodegradable under normal physiological conditions (Becker et al, 2001). Once in a gel form, alginate dressings will also promote healing and epidermal regeneration.

These dressings have been used to treat a variety of wound types, in particular, wet wounds which also have a degree of sloughy tissue. The gel which is formed when the product absorbs exudate, prevents the wound from drying out and assists in the process of debridement. This function precludes alginates from being used in dry or low exuding wounds, as they may adhere to the wound bed.

Haemostasis

Coagulation is an important part of haemostasis where there has been injury to the body. Once a vessel has been damaged, the lining of the vessel, the endothelium, releases phospholipid components known as tissue thromboplastin, which initiate a chain of events to attract platelets to the injury site, which will form a plug or clot (Furie and Furie, 2005). This is known as primary haemostasis. In addition to forming the platelet plug, the local vessels contract to minimise bleeding. The clot traps red blood cells. Platelets bind to collagen which have glycoprotein receptors which form links with collagen fibrils, thereby activating the platelets. Activated platelets become sticky and fuse together.

Secondary haemostasis occurs simultaneously and is recognised by the presence of proteins known as clotting factors, primarily factor VII and factor VIII, collagen and other clotting factors. These are recruited to the injury site by von Willebrand factor (Furie and Furie, 2005) which exists in the vessel walls. Prothrombin is altered to form thrombin which, in turn, converts fibrinogen to fibrin, the basic building block of the haemostatic clot. Once the clot forms, a number of enzymes are employed to reduce the size of the clot through fibrinolysis and this is controlled by plasmin.

Fibrin strands bind with collagen in the clot adding strength and stability. Calcium ions are essential throughout the process, and are of particular importance in the formation of fibrin polymers.

Beyond the initial clotting response, a number of growth factors are released by platelets. These are employed in wound healing and tissue repair. This platelet derived growth factor (PDGF) is responsible for angiogenesis.

Achieving haemostasis is an essential part of the healing process for both acute and chronic wounds.

Role of alginate dressings in haemostasis

Alginate dressings are fibre dressings which are formed from alginic acids (mannuronic and guluronic), extracted from seaweed species (Timmons, 1999). The fibrous dressings form a gel when in contact with wound exudate through an ion exchange process (Heenan, 1998).

The ratio of mannuronic to guluronic acid within the dressing will determine the clinical properties of the product, such as speed to gelling, the strength and the amorphous nature of the gel. The compound within the alginate dressing is calcium alginate which, when in contact with exudate, will form sodium alginate and calcium ions. The sodium ions are present within exudate and plasma. The availability of calcium ions at the injury site helps to support the normal clotting process, and this has been shown to significantly reduce clotting times, in some cases up to 54% compared with controls (Kaneda et al, 2008).

Sorbsan® calcium alginate dressing

Sorbsan® calcium alginate dressing (Aspen Medical Europe) is prepared as a textile fibre, and presented as a loose 'rope' or packing for cavities, a ribbon for narrow wounds or sinuses, and a flat non-woven pad for application to larger open wounds.

Sorbsan is of particular use in cavity wounds, and has been used in pilonidal sinus wounds as a dressing which conforms to the wound bed, is easily rinsed out and reduces the pain experienced by patients with pilonidal sinus wounds (*Figure 1*) (Timmons, 2007). As a flat sheet dressing, Sorbsan is also used to treat venous leg ulcers. Sorbsan Plus, which consists of a sterile, calcium alginate wound contact layer, bonded to a secondary absorbent viscose layer, provides added absorbency and can be used under compression.

The moist wound healing environment which alginates create promotes the formation of granulation tissue. As said, the gel is easily rinsed out of a wound, thereby ensuring that the dressing does not inhibit the formation of new tissue (Heenan, 1998).

To provide clinical evidence in support of Sorbsan being an affective haemostatic agent when in contact with human blood, two *in vitro* studies were conducted. These studies also tested two other dressing products: Kaltostat® (ConvaTec), a sodium-calcium alginate and ActivHeal AquaFiber® (AMS Medlogic), a CMC-alginate mix as both have claimed haemostatic properties. A non-alginate control material was also used.

In vitro study I — haemolysis test

This test was to evaluate the dressings' 'inability' to break the red blood cells, therefore demonstrating each dressing's compatibility with human blood and potential for haemolytic activity (Wright, 2008a). The 'inability' to release the haemoglobin from the red blood cell is measured as a percentage. The test criteria for non-haemolytic was set at <5%.

Results and interpretation

The results identified Sorbsan Plus and Kaltostat to have non-haemolytic properties with results falling within the <5% threshold, thus demonstrating their 'inability' to release haemoglobin when in contact with human red blood cells.

The results for Sorbsan Flat were marginally above the 5% threshold at 6.8%, demonstrating weak haemolytic properties, while those for the ActivHeal AquaFiber appeared to have stronger haemolytic properties with a result of 21.5%. However, when compared against a gauze control which provided a haemolytic response of 100%, all the alginate-containing dressings within the study provided results of acceptable biocompatibility properties.

In vitro study II — haemostasis test (bespoke method)

This study was undertaken to investigate not only Sorbsan's compatibility in contact with blood, but also whether the sodium-calcium ion exchange in alginates has a positive effect on primary haemostasis (Wright, 2008b).

This bespoke haemostatic test using spectrophotometer techniques was developed by Robert Duward of Safepharm Laboratories, and the statistical evaluations of the results were performed (Wright, 2008b). The test uses citrated whole human blood. The process of citration removes clotting factor IV (calcium ions) and is commonly used to prevent clotting during blood screening tests. The scope of this test was to evaluate the degree of 'ability' of the red blood cells from the citrated blood to clot when in contact with a selection of wound dressings.

The test criteria were to demonstrate the ability for human blood to coagulate when in contact with the selected alginate dressings, i.e. Sorbsan, Sorbsan Plus , Kaltostat, and ActivHeal AquaFiber. The amount of coagulation achieved in contact with each test sample is quantified by measuring the amount of unclotted blood, expressed as a percentage of total citrated blood applied.

Results and interpretation

A statistical evaluation was conducted using the spectrophotometer data, based upon the Mann-Whitney Test. The efficacy of Sorbsan Plus to promote haemostasis (clotting) was significantly superior when compared with the other alginate dressings within this study: Kaltostat when compared with Sorbsan Plus ($p=0.02$); ActivHeal AquaFiber when compared with Sorbsan Plus ($p=0.03$). The efficacy of Sorbsan (flat, ribbon and packaging) to promote haemostasis was statistically equivalent to Kaltostat and significantly greater than ActivHeal AquaFiber ($p=0.02$).

Discussion

The results of these tests support the earlier work of Beldon (2004) and O'Donohue et al (1997), where calcium alginate dressings were used to manage bleeding in split-thickness skin grafts. Both of these studies highlighted the value of alginates as haemostatic agents. O'Donohue carried out a trial of calcium alginates compared with paraffin gauze on donor sites, with 21 out of 30 patients in the alginate group healing in ten days, compared with only seven of 21 in the paraffin gauze group.

In a study of forty patients with donor site wounds, Beldon (2004) compared alginate dressing with paraffin gauze, with or without film dressings, and demonstrated that alginate with film

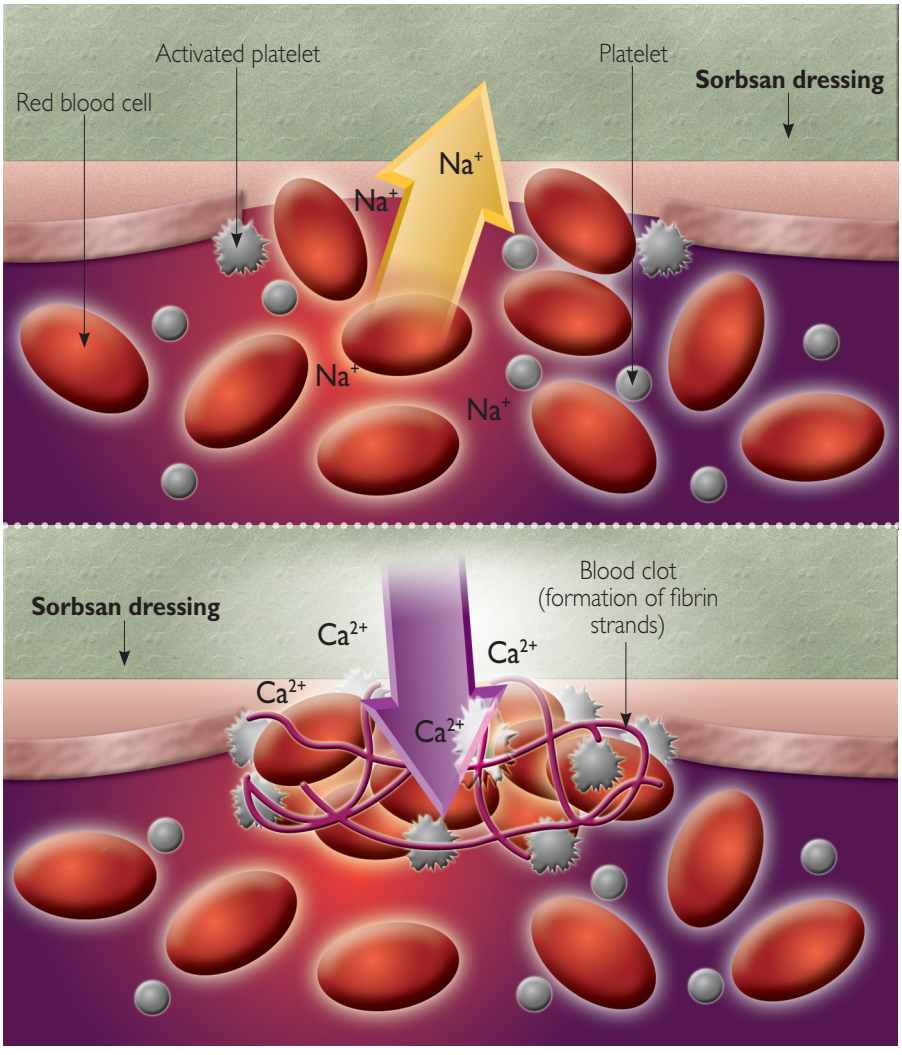

Figure 1. These images demonstrate the sodium calcium exchange that occurs when Sorbsan dressing is applied to a bleeding wound and the calcium ions provided by the dressing to the damaged area assist in the coagulation cascade, or primary haemostasis.

achieved healing faster and was much less traumatic for the patient than the other groups in the study.

Therefore, in wounds with minor bleeding, *in vivo* and *in vitro* data demonstrates that alginate dressings have proven effective.

Conclusion

Alginate dressings are indicated for the treatment of a number of wound types, and are particularly useful in managing sloughy wounds with moderate to heavy levels of exudate. Alginates are also ideal for treating cavity wounds and, as Sorbsan forms a soft conformable gel, it can be used to treat non-uniform cavities. In addition to the wound healing function, alginate dressings can be used to promote haemostasis in bleeding wounds. The calcium sodium ion exchange which takes place when the dressing is in contact with wound exudate allows calcium ions to be released into the wound. As calcium is a normal part of the coagulation response, this release of calcium assists in haemostasis.

Although alginates have been promoted as haemostats in the past, there is now more evidence to suggest that they are clinically beneficial (O'Donoghue et al, 1997; Beldon, 2004). In particular, Sorbsan Plus has been identified by the bespoke test and backed up by the haemolysis test as having good haemostatic properties, which may increase the indications for its use in clinical practice. Sorbsan Flat, Ribbon, Packing and Plus are proven to be suitable for the management of minor bleeding in wounds. WUK

Key points

- Alginates have an important role to play in wound care due to their ability to absorb, conform and provide moist wound healing properties.
- Some patients present with wounds which have minor bleeding, such as donor sites which would benefit from the use of alginate products.
- In tests, Sorbsan Plus proved to be an effective haemostat with excellent biocompatibility.

References

Becker TA, Kipke DR, Brandon TA (2001) Calcium alginate gel: a biocompatible and mechanically stable polymer for endovascular embolization. *J Biomed Res* **54**: 76–86

Beldon P (2004) Comparison of four different dressings on donor site wounds. *Br. J Nurs* **13(6)**: S38–S45

Heenan A (1998) Frequently asked questions, Alginate dressings. World Wide Wounds. Available online at: www.worldwidewounds.com/1998/june/Alginates-FAQ/alginates-questions.html# [accessed October 2009]

Furie B, Furie BC (2005) Thrombus formation in vivo. *J Clin Invest* **115(12)**: 3355–62

Kaneda K, Kuroda S, Goto N, Sato D, Ohya K, Kasugai S (2008) Is sodium alginate an alternative haemostatic material in the tooth extraction socket? *J Oral Tissue Engineering* **5(3)**: 127–33

O'Donoghue JM, O'Sullivan ST, Beausang ES, et al (1997) Calcium alginate dressings promote healing of split skin graft donor sites. *Acta Chir Plast* **39(2)**: 53–5

Thomas S (2000) Alginate dressings in surgery and wound management — Part 1. *J Wound Care* **9(2)**: 56–60

Timmons JP (1999) Alginates and hydrofibre dressings. *Prof Nurse* **14(7)**: 496–9, 501, 503

Timmons J (2007) Diagnosis, treatment and nursing management of patients with pilonidal sinus disease. *Nurs Standard* **21(52)**: 48–56

Wright R (2008a) *Blood Compatibility — Haemolysis Test, Direct Contact Method* (ISO 10993-4). Pharm Labs. Technical File # 1& 2, Aspen Medical Europe Ltd. Data on File

Wright R (2008b) *Haemostatic Activity Test Report*. Safepharm Laboratory. Technical File # 1& 2, Aspen Medical Europe Ltd. Data on File